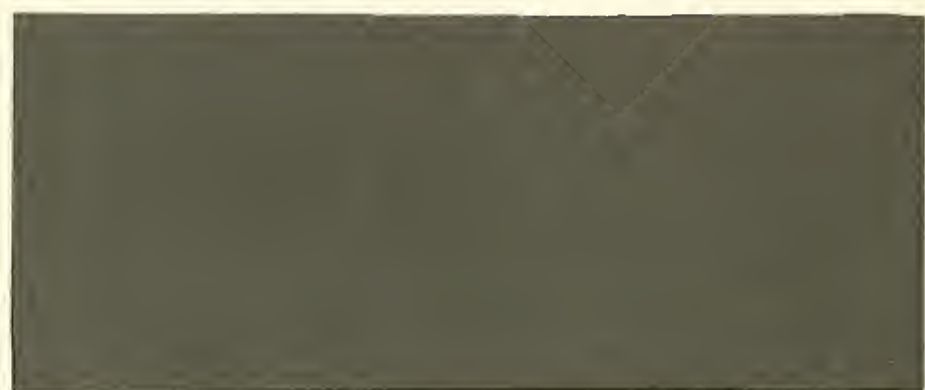WORKING PAPER

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A NOTE ON THE APPLICATION OF

COMPUTER TECHNOLOGY TO EDUCATIONAL GUIDANCE

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Introduction

I want to say at the outset that I am totally innocent of either
theoretical knowledge or practical experience in the field of educational
guidance. This heady state of affairs obviously enables me to take a
wholly detached view of the problems and possibilitities of applying computer
technology in that area. Consequently this will be a blue sky contribution,
aimed chiefly at stirring up debate in novel and most likely outrageous
directions. It will then be your responsibility to tell me whether the
suggestions that I propose have anything all to do with the realities of
the world of guidance as you know it.

A quick and dirty overview of what computers do

Computers are of course able to do nothing more than what you can
do yourself by pencil and paper. Yet the statement is deceptive. Logically
to be sure computers are awfully simple beasts: All they can do is 1. sense
whether a magnetic point exists or not, 2. transfer such a point from one
location in their internal memory -- or storehouse -- of such magnetic points
to another location in memory, and 3. "add" two magnetic points together
according to the simplest of all possible rules, namely according to binary
arithmetic -- which I am sure you are all familiar with.

The great power of computers is, as you also know, largely due to two factors, namely: <u>i</u>. their great speed in performing their simplistic operations on these electro-magnetic points, or on symbolic information represented in terms of combinations of such magnetic points, and <u>ii.</u> the fairly large capacity of computers' memory storehouses, serviced as these memories are by rapid and extremely error-free access to and from every item stored in them.

Knowing these two features of the power of computers immediately allows us to raise two basic design questions, which in turn help suggest how machines might come in useful in, for example, the administration of highschool guidance programs:

<u>a</u>. What could you as a guidance worker do in your daily work, which you do not now do, if you had immediate access at your fingertips to an order of magnitude more data about say students' class performance and intellectual abilities, their personal goals and career aspirations, family background, etc., -- might it be useful e.g. if you could make direct and instant comparisons between the states of these variables and the "expected" values on the same variables for sub-populations of "similar" students?

<u>b</u>. What could you as a guidance worker do in addition to what you do today if you had available an order of magnitude more powerful computational routines for analyzing or reducing the available information about student populations -- for example if you could get instant evaluations of rarely encountered or hard-to-preprogram "special cases"?

In the three or four areas of computer applications to guidance that I am going to suggest below both of these design heuristics were brought into play to help generate the ideas. But before we focus on the latter let me say just a word or two about the current state of the art of computer technology, and touch very briefly on the goals and activities of Project MAC at MIT -- the initials of which stand for machine aided cognition or multiple access computer systems -- both of which topics I gather you have some interest in exploring.

First, second, and third generation computers

Let us first understand what is meant by the commonly made classification of computers as being either first, second, or third generation. It is only a little over ten years ago that the first generation of computers started out to conquer the world, largely through exploratory investigations by graduate students in university laboratory and through direct one-to-one mechanization of highly routinized, punched card type information processing in business organizations. These first generation machines had very small mechanical drum memories, with enough room for only about two to four thousand word symbols, performed input/output operations and computations at comparably slow speeds, and needed someone resembling a gremlin/wizard to "talk" softly to them and literally kick them in the right places in order to make them go through their paces. In short, early computers resembled one-man women: They understood a very special and subtle language -- socalled machine language -- and were subserviant to one man only, i.e. their operator, who had to play them very carefully by ear to get them to anywhere near climax.

Second generation computers have only been around five years or so. These are the ones which as they replace human clerical labors put <u>more</u> persons to work expanding the now possible, and previously prohibitively expensive, uses of organizational information, than they seem ever able to displace by their labor saving machinization of an organization's information hand-processing. On the other hand, there is little doubt that these computers have made people -- like mathematicians, engineers, professors, and managers -- hopelessly obsolete, unless they've really made the effort to conquer the new technology in their own work.

Second generation computers are characterized by <u>a.</u> an order of magnitude larger immediate access (core) memory; <u>b.</u> order of magnitude greater computation speeds; <u>c.</u> a layer of technicians and machine tenders who interpose themselves between, and who operate the computer on behalf of mortal "users", who may in fact never have laid eyes on the machine herself. These computers speak a diversity of languages which with little formal training enable a novice user to state his problem and thus perhaps obtain partial satisfaction from the common facillity. In effect these, second-generation computers have produced the almighty Computation Center, wherein everyone in the organization goes, usually in overflow members, patiently to await the machine tenders' batch processing of their respective programs. This distant form of communication with the computer, enabling as it does a user to perform only a few steps at a time in the "debugging" of his programs, can and usually does result in frstratingly long drawn-out periods of program construction.

Third generation computers bring man and his machine together again.
These machines are so large and so fast that each one of a fairly large
number of users -- about 50 to 200 of them at the moment -- can sit down
with a console in his own living room, hooked up to the central computer,
and there use the central processor as if none of the other users existed.
The computer simply services each man for a short instant of time, round
robin fashion -- the total time around and back to the first man again
being so short that the latter (almost) does not perceive that the machine
has not been his very own all along. Consider cinema movies as an appro-
priate analogue illustration: the time between each picture frame is so
short that it looks, even to an inititated viewer, as if the series of
pictures before him are "in fact" one continuously flowing motion.

Brief overview of project MAC

MIT's project MAC is one of the better known forerunners and experi-
mental proving grounds for third generation computers. The overall goal of
project MAC is to provide a laboratory for the exploration of problems
involved in creating and operating a truly general purpose computer "utility",
in the same sense that radio, television, and telephone communication and
electric power are general-service utilities today. More operationally
stated the objectives of project MAC are three-fold:

a. to design and test out the hardware components necessary to imple-
ment a time-sharing computer facility;

b. to design system programs, software logic, and input/output
languages suitable for on-line problem solving by socalled real
time man-machine interaction, i.e. by men using computers as
engineers use slide rules;

c. to encourage non-systems users to restate their scientific and
technical problems in a form which makes them more efficient for
solution with the on-line interactive possibilities, and then to
provide the auxilliary services that enable these experimental
problem solvers to use the system in a meaningful way, thus providing
Project MAC invaluable data and operational experience regarding the
many unforseen technical as well as non-technical problems involved
with actually running a third generation, real-time computer utility.

If I were forced to answer the question point blank, "What of of the
research that is going on at MAC is relevant to someone interested in educa-
tional guidance?" then I would have to respond: "Directly relevant, probably
nothing." Having a look at the recently issued 1965 Annual Report covering
all MAC sub-projects now in operation would quickly set your mind at ease in
that regard. However, indirectly, in the sense that the information proces-

sing capability that is here being explored is going to change the hither-
to severely limited scope of most advisory services available today, whether
educational, medical, legal, or otherwise, the work that is now going on at
project MAC and similar installations around the country is potentially quite
relevant.

In this respect I would like to single out the M.I.T.'s libraries'
Technical Information Project (TIP) as being the MAC activity you may want to
pay more closely attention to.[1] Project TIP has succeeded in computerizing
library reference file covering 25 of the professional journals which account
for about 70% of all the physics papers being published in the world today.
The user of this library "may perform search and retrieval operations by means
of a special language that consists of several dozen words to control search
programs" for locating, for example, all recent references relevant to a given
physics topic, all articles which cite a given reference, or only those arti-
cles which are related to a set of issues in a certain prespecifiable manner.[2]

The other projects underway at Project MAC are of a sufficiently special-
ized technical nature that I'd be hard put to summarize them adequately for
you in the few minutes available. Suffice it to say that computer engineers
are only now starting to emerge from their largely self-contained world of
interacting solely with each other and their machines, and are starting to
pay more attention to the limitations imposed on the implementation of their
systems, deriving from the fact that these systems often upset, or run counter
to, the established mode of doing business in the fields they attempt to service.
With this as a suitable introduction let us now consider very briefly four
more or less obvious applications of computerized information technology to
the field of educational guidance.

University-highschool guidance feedback loop

The presence of a large scale file memory system, which may be updated and accessed by direct hook-up telephone from anywhere in the country, should enable highschools for the first time in history to follow their product, i.e. their students, into their first two or threee years of college, obtaining from the universities for each one of these students a wealth of diagnostic statements about the quality and quantity of their highschool preparation in various academic subjects, and along other relevant dimensions of personal development. This would in turn enable highschools to adapt their curricula and academic programs more rapidly, and probably much more meaningfully, in directions that they at present only vaguely suspect they may want to change in.

Indeed it seems to be an unhappy feature of the educational system as it stands that universities, which are continually trying to change and upgrade their undergraduate course content and teaching methods, do so in an environment that is almost completely cut off from the very institutions responsible for producing their academic raw materials, in form of highschool graduates. To be sure, several of the top-flight universities -- besides the traditional schools of Education -- have offered constructive suggestions regarding what and how highschools might teach in certain subject areas, like for example introductory physics, chemistry and certain parts of mathematics. Unfortunately any one-shot set of solutions, if they are adopted by highschools, no matter how good the ideas may be at the time of their inception, will rapidly become obsolete in the face of the revolutionary expansion and modification of knowledge that is currently taking place at the university undergraduate level. Indeed, by becoming institutionalized as some from of panacea, such one-shot changes may constitute a serious hindrance to the future flexibility and adaptability to change of any school's educational program.

What seems called for in effect is an information processing system sufficiently powerful to hook up in real time the two sub-systems, the high-school and the university, which are in fact so integrally related in the minds of each and every individual student. Thus highschools will <u>themselves</u> be able to diagnose how well they are doing, what their problems are, and how effective their efforts to cope with changing university and occupational demands have in fact turned out to be. Possible participation in the design phases of an education insitutional information system of this type is indeed an exhilarating prospect for this writer to contemplate.

I. <u>Question and answer service for educational guidance</u>

At least two related strategies immediately came to mind when one contemplates how one might utilize information processing technology in face-to-face student guidance work. For lack of better terms call one approach the "counsellor centered" and the other the "student centered" approach to automating educational guidance programs.

<u>a</u>. Counsellor centered guidance automation:

This approach may be viewed as an extension of Newell, Shaw, and Simon's well known work on the simulation of human cognitive processes by digital computers, in which the information sorting-and-moving power of machines is utilized to describe, in as much detail as human subjects are able to recount, the intellectual processes whereby the latter reach solutions to complex problems.[3] Kleinmuntz has for example reported one computer program which does a fair job of simulating the thinking process of an experienced analyst's interpretation of scores on a Minnesota Multiphasic Personality Inventory (MMPI) personality test.[4]

Closer to home Cogswell and Estavan at the Systems Development Corpora-
tion report having done the same thing for a highschool guidance counsellor.[5]
The former were in effect able to mechanize a good portion of that part of a
counsellor's job which had to do with his checking out of students' suggestions
about what courses they thought they might take next year. That is to say,
a student was able to sit down with a console, read in his proposed program,
and then have the machine run through the common sort of checks and tests on
his academic program proposals -- examining it say for necessary prerequisites,
sequences required to get into college, breath of subjects etc. -- much in the
same way that one particular counsellor was observed to do it. The machine
would then tell the student what it "thought" of his program, and would in
non-standard cases request that the student take the matter up with his
counsellor -- who was then also informed by the machine about what had lead
to identify the student's unresolved problem.

In other words, the guidance counsellor's job was taken as a fixed
given. The computer systems designer's job according to this strategy is
to try to automate and facilitate as much as possible a counsellor's execu-
tion of his traditionally defined job. And have no doubts about it, an
amazing amount of a counsellor's judgement can be, and will be, routinized
in this seemingly pedestrian manner. Consider for example the successes
that have already been scored in this regard in fields like medical diagnos-
tics, trust investments, engineering design, chess playing, etc.[6] Another
question entirely is of course whether this form of counsellor's job automa-
tion will be economically feasible, even with extremely inexpensive and
ominipresent computing machines.

b. Student-centered information processing:

An even more challenging prospect for computer applications is presented by the second strategy indicated above. This approach entails our first ridding our minds of all preconceived notions regarding what guidance counsellors in fact do or do not do during guidance interviews, and rather to ask ourselves what it is that students really want, or ought to want, from an ideal guidance program -- and then to examine if and how present or conceivably information technology could possibly help fill such an ideal prescription?

I am not going to compete with you in   speculating about what it is that students _really_ want and need when they seek out guidance counsellors -- if that they do. But I will suggest that what students want is largely an empirical question, to which the students themselves, their parents and teachers, if given half a chance, can supply most of the answers. For example, what indeed does go through the minds of a student and his parents when mulling over his career goal or educational possibilities? What information does the student dearly wish that he had, of kinds not now available either due to its special nature, students' ignorance of its existence, or due to a failure on our part to record and process such information and make it readily available to the potential consumers?

Once we start collecting systematic answers to these, at least on the surface, quite pedestrian questions there seems no reason why we cannot design an information file, and routines for processing it, which, with very little instruction, would allow a student and/or his parents to sit down with a

console and trial-and-error wise explore the many choice possibilities for an educational career-path that usually lie within the capabilities of that particular student, which are now perhaps blocked to him simply because no one had the wits, the time, of the perspicacity to point them out to him in a language and context that he could deal with. Give a student half a chance to explore and meaningfully plan his own future and it is an easy guess that the resulting boom in this kind of "student-machine self guidance" will quickly outstrip anything that a professional counsellor in his wildest dreams could dare hope for in the way of an increased market demand for his services.

Conditional testing services

In closing let me mention very briefly two other obvious areas of application for the new information technology: Educational testing as it is usually performed today is a standardized and, perhaps therefore, a heavy-handed and non-differentiated shot-gun approach to student guidance. Whereas paper and pencil tests may originally have been conceived of as a tool for educational diagnosis, "testing" at the moment seems to have stabilized as being little more than a brute force method for justifying the screening out of socalled "undesirable" students by "selective" school systems.

Consider how computer automated factories have allowed us dramatically to cut down the traditionally high costs of engineering-design and production line set-up, which traditionally necessitated extremely long assembly-line mass production runs of any one product model in order to make it economically feasible. For example, in a computer controlled plant one will be able to

designate a different design for each piece that passes through the production line, without thereby materially increasing the total cost of the product. Similarly it seems reasonable that a properly constructed computer-controlled conditional battery of educational tests would be able to probe and explore any given student's idiosyncratic set of intellectual problem areas, by zeroing in on particularly strong and/or weak parts of his total knowledge, or of his aptitude for learning, much in the same way that programmed instruction sequences now lead a student back and around whenever he has made a mistake in reasoning during acquisition of a piece of knowledge.

In short, computer-controlled conditional testing programs would enable us, it seems, to get adequate diagnostic ability built into pencil and paper tests, such that, perhaps for the first time, we could begin to say that testing helped students to identify their own educational problems as much as its practice now seems to help admissions officers justify their rejection of all those students who do not measure up to a much too inflexible "standard" of learning.

National educational planning capability

Finally, as we now realize that we are living in a great society, let me simply point to the possibilities for macro-educational planning that appear possible with a computer-based national pool of information about our young people's career directions, educational plans, and capabilities: Here finally is the possibility to make prognosis and take remedial action regarding underdeveloped areas of the nation, or regarding the unbalance of

future distributions of certain types of skills and educational preparation,

sufficiently early that remedial action may be taken. The information

necessary to do this job surely exists today, scattered however, in t he folders

of education counsellors throught the country. Our job will now be to put all

that information together, so that we can begin to see the true regional

and socio-economic educational patterns of the country emerge.

NOTES AND REFERENCES

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